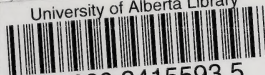


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Biology 20

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Module 4 MECHANISMS OF POPULATION CHANGE



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Module 4 MECHANISMS OF POPULATION CHANGE

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Biology 20
Module 4: Mechanisms of Population Change
Student Module Booklet
ISBN 978-0-7741-3026-4

Cover Art: © Natalia Bratslavsky/Dreamstime

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Students	✓
Teachers	✓
Administrators	
Home Instructors	
General Public	
Other	



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- Alberta Education, <http://www.education.gov.ab.ca>
- Learning Resources Centre, <http://www.lrc.education.gov.ab.ca>
- Tools4Teachers, <http://www.tools4teachers.ca>

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Biology 20

Unit **B** Ecosystems and Population Change

Module 4—Mechanisms of Population Change

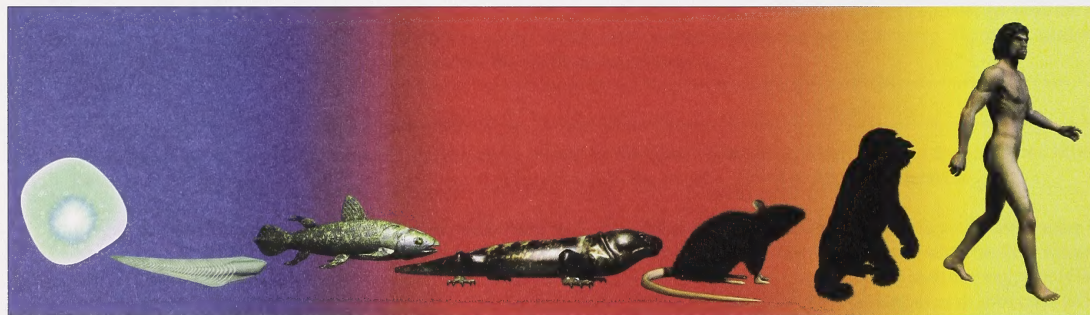
Module Introduction

In this module you will examine how populations evolve or change over time. You will look at the processes, requirements, and evidence for evolution. This module will use the ecological terms discussed in Module 3 and relate them to population change. Prior knowledge about the role sexual reproduction plays in creating change will be explored.

Humans were not always the emotionally and mentally complex beings that they are today. Could you imagine what the world would be like if nothing had changed from the age of dinosaurs or from the prehistoric time of Neanderthals? How have people become such different animals?

Looking at ancestry helps us to see where new species branch off from their origins. Knowing how organisms are classified, as you learned in Module 3, can show where new species arise by tracing backwards through the levels of classification. It is a method for tracing ancestry. In order to hypothesize why organisms diversify as Earth ages, we must look at factors such as genetic mutation, sexual reproduction, and survival of the fittest. There are several theories that serve as the basis for modern ideas of evolutionary change. Researchers and scientists have found evidence that they propose is proof that species have evolved from ancestral forms. As you work through this module, these ideas will help you explore the question “How do populations evolve?” This will lead you to predict how new species can arise.

By the end of this module you will have completed lesson assignments that are to be marked by your teacher and others that help to build confidence in your ability to understand, interpret, and express key course concepts. Everything should be saved in your course folder so that you are able to review pieces of information for exams, project work, or discussions.

 Big Picture

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Have you ever heard of or seen one of the “Planet of the Apes” movies? In these shows, apes had evolved into intelligent and advanced beings that took over the planet from humans. The premise was that they continued to evolve and humans did not.

Take some time to look at the illustration above. What thoughts come to mind when you look at it? Did the word *evolution* pop into your head? Have you ever considered the idea that humans are related to rodents? What kind of proof exists for the illustration above to be true? Is evolution still occurring or is it finished, as the illustration seems to indicate? As you look at the illustration, you may ask yourself how the blob became the sea creature that became the human.

In this module you will learn how a population of “blobs” evolved into a population of sea creatures as a stage toward another movement of evolution. You will have to think in terms of enormous amounts of time and many, many generations of organisms. Some of the ideas about genetic variety and the inheritance of characteristics will be familiar to you from Grade 9 Science.

You will explore the following essential questions in this module:

- How do mutations create species variability?
- Why is sexual reproduction important to the process of evolution?
- How do theories explaining evolutionary change compare?
- What theories attempt to explain the pace of evolutionary change?
- What proof is there that present-day species evolved from ancestral forms?
- What conditions are necessary for speciation?

In This Module

Lesson 1—Adaptation, Variation, and Natural Selection

Unless you are an identical twin, the only other human who looks the same as you is your reflection. Humans have many differences between them that create unique individuals. In this lesson you will look at these variations and see how they can help humans survive.

The following questions will be explored in this lesson:

- How do mutations create species variability?
- Why is sexual reproduction important to the process of evolution?

Lesson 2—Developing Theories to Explain Change

Modern theories explain evolution on a global scale. There are also theories that became the foundation for how scientists view evolution within populations.

The following questions will be explored in this lesson:

- How do theories explaining evolutionary change compare?
- What theories attempt to explain the pace of evolutionary change?

Lesson 3—Evidence for Evolution

You have seen the proof supporting evolution if you have ever looked at a dinosaur fossil. Organisms have changed over time, and there is a substantial amount of evidence to show these changes.

The following question will be explored in this lesson:

- What proof is there that present-day species evolved from ancestral forms?

Lesson 4—How New Species Form

Dinosaurs and humans never existed during the same time period. Humans (*Homo sapiens*) became a species about 150 million years after dinosaurs ruled Earth.

The following question will be explored in this lesson:

- What conditions are necessary for speciation?



Module Assessment

You will be graded according to the work you complete for the lesson assignments and the module project. The module project is the final assignment for Module 4. See the Module Summary and Assessment section for more information about the module project.

Lesson 1—Adaptation, Variation, and Natural Selection

Get Focused

The girls on a soccer team are all very close in age, but they may not all have the same skill level. You've probably played on a sports team with players of different abilities. Why are some people better soccer players than others? If all individuals had identical playing ability, how would you pick an MVP? What about picking a goalie? How could you choose the best player to put on the all-star team?



© Bonnie Jacobs/Dreamstime

Evolution, like a soccer team, depends on individuals having different characteristics. Individuals with helpful characteristics will be able to survive better. How is it decided if a characteristic is helpful or not helpful?

You may have noticed that individuals from the same family look similar. Maybe you have your mom's nose or the same eye colour as your dad. Are you a good soccer player? Are your parents good soccer players? Some characteristics can be passed from one generation to the next. How have these characteristics helped you survive and thrive? What characteristics have made your life more difficult?

In this lesson you will look at the differences or variations that exist within species, how variations are created, and what process leads to changes in populations.

In this lesson you will explore the following essential questions:

- How do mutations create species variability?
- Why is sexual reproduction important to the process of evolution?

Module 4: Lesson 1 Assignment

In this lesson you will complete the Lesson 1 Assignment in the Module 4 Assignment Booklet.

- TR 1. Peppered Moth Simulation
- Watch and Listen: Sickle Cell Anemia: An Advantage or a Disadvantage?
- Watch and Listen: The Peacock and Natural Selection
- TR 2. Selective Pressures
- LAB: Finch Beak Depth

The other questions in this lesson are not marked by the teacher; however, you should still answer these questions. The Self-Check and Try This questions are placed in this lesson to help you review important information and build key concepts that may be applied in future lessons.

After a discussion with your teacher, you must decide what to do with the questions that are not part of your assignment. For example, you may decide to submit to your teacher the responses to Try This questions that are not marked. You may decide to record the answers to all the questions in the lesson and place those answers in your course folder.



Explore



Read

Variation is all around you—it's the differences between all living things. No two puppies or humans look and behave exactly the same. Some variations may give an organism a survival advantage, some may cause a disadvantage, and some will not make a difference in the organism's survival.

A variation that gives a survival advantage to an individual is called an **adaptation**. Adaptations allow an individual to survive and reproduce. When an organism reproduces, it can pass on adaptations to its offspring, giving them the same survival advantages. These adaptations continue to be passed on from parent to offspring over many generations as long as the adaptation gives the organism a survival advantage.

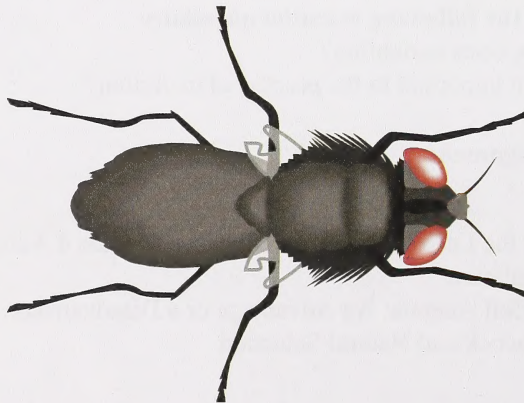
If the environment changes, an adaptation that once gave a survival advantage may now give a survival disadvantage to an organism. In the new environment, the organism will not survive to pass on its genetic information.

Variations can be created during sexual reproduction (when genetic material from both parents is mixed up) or through **mutations**.

variation: visible or invisible differences between individuals

adaptation: a beneficial variation that helps an organism survive

mutation: a change in the genetic material of an organism (DNA)



Read pages 114 to 117 in the textbook and page 118 to “Natural Selection.” You will become familiar with variations, adaptations, and mutations.

 Self-Check

SC 1. Sharks have an excellent sense of smell. Is smell an adaptation?

SC 2. Give an example of how sexual reproduction leads to variations among individuals in a population.

SC 3. What is the difference between a mutation in a somatic cell as compared to a mutation in a reproductive cell?

SC 4. Give an example of a mutation that provides a selective advantage.

SC 5. Give an example of a mutation that provides a selective disadvantage.



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Check your work with the answer in the appendix.

 Discuss

How does sexual reproduction lead to variation among individuals in a population? Create a thorough response to this question. Post your response in the discussion area, and view the other posted responses. Is your explanation easy to understand when compared to classmate responses? Will you make any changes to your explanation after reading other student explanations? Make any changes you like and repost your final response to the question. Your teacher may choose to make this posting an assignment question.



Try This

TR 1. Peppered Moth Simulation

Use the peppered moth simulation to see how a variation that at one time gave a selective advantage became a disadvantage when the environment changed.

The peppered moth (*Biston betularia*) has two colour variations in its population—light and dark. Before 1848, the dark variation was very rare. In the middle of the eighteenth century, the Industrial Revolution started to change the peppered moths' environment. The soot released from industries covered trees and darkened the forest environment. After the Industrial Revolution, 90% of the peppered moths were of the dark colour variation. What caused this change in colour variations?



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Directions

Step 1: Go to www.learnalberta.ca. You may be required to input a username and password. Contact your teacher for this information. Enter the search terms “Gizmo Natural Selection” in the search bar. Choose the item called “Natural Selection (Grade 11).”

Step 2: Read and follow the steps in the “Exploration Guide.” Try to answer the questions as you go through the guide.

Step 3: After you have run this simulation for a light and dark forest, try the Assessment Questions listed below the simulation.

Step 4: Answer questions 1 through 3 for the Peppered Moth Simulation in your Lesson 1 Assignment. Also save your responses in your course folder.



Read

Mutations are changes in the genetic material (DNA) of an organism. Mutations are naturally occurring at a steady rate in populations. This rate can be increased if **mutagens** are introduced into the environment.

mutagen: something that causes an increased rate of mutation

Common mutagens include the following:

- X-rays
- nuclear rays
- UV rays
- some chemical compounds

What happens when a mutation is passed on to offspring?

- Some mutations are harmless and have no effect.
- Some mutations may create a new variation that provides a **selective advantage** and increases the offspring's chances of survival.
- Some mutations may create a new variation that provides a **selective disadvantage** and reduces the offspring's chances of survival.

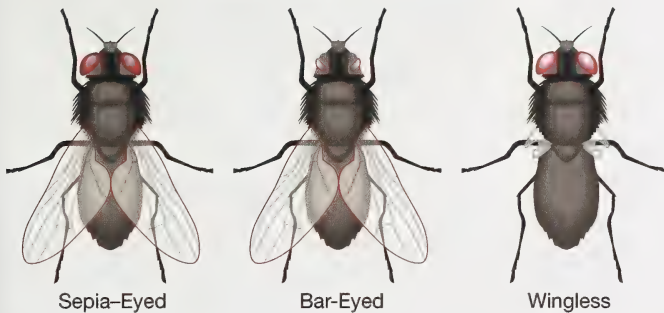
selective advantage: an organism's variations increase its chances of surviving

selective disadvantage: an organism's variations reduce its chances of surviving

Next is an example of a mutation creating a variation in a population of fruit flies.

Parent fruit flies were bombarded with X-rays. The parents then mated with healthy fruit flies, and the offspring had many mutations. The following image shows examples of some of these mutations.

Genetic Mutations of the Fruit Fly



The wingless mutation will cause a disadvantage to the fly, and the offspring likely will not survive to reproduce. Since the offspring doesn't reproduce, it will not pass on the disadvantageous mutation.



Watch and Listen

Sickle Cell Anemia: An Advantage or a Disadvantage?

Sickle-cell disease is caused by a chance mutation in the hemoglobin molecule found in red blood cells. The mutated gene is passed on from generation to generation. This disorder causes red blood cells to become crescent-shaped instead of round and smooth. (See "Figure 4.4" on page 117 of the textbook.) This change in shape causes blood clots and many other medical problems.

There is an advantage to the sickle-cell gene. Do an Internet search to find the advantage of having one of the sickle-cell genes. Try using the keywords "pbs evolution library sickle cell" to see if you can find a video about sickle cells.

Discuss, either orally or in writing, the following questions:

If you knew you had the sickle-cell gene, would you choose to have children? Would the negatives prevent you from having children? Or would the positives outweigh the negatives? Prepare your thoughts, and post them in the discussion area. How do your thoughts compare with those of your classmates? Once you have read other postings, consider your answers. You may modify your response before submitting your final discussion as part of the Lesson 1 Assignment.

Sickle-Cell Activity Marking Rubric

	4	3	2	1
Positives	The student demonstrates a superior understanding of the positive aspects of the sickle-cell gene.	The student demonstrates an understanding of the positive aspects of the sickle-cell gene.	Few positive aspects of the sickle-cell gene are given.	The positive reasons are not adequate.
Negatives	The student demonstrates a superior understanding of the negative aspects of the sickle-cell gene.	The student demonstrates an understanding of the negative aspects of the sickle-cell gene.	Few negative aspects of the sickle-cell gene are given.	The negative reasons are not adequate.
Opinion	The student takes a firm stand on the issues based on the positives and negatives explored.	The student takes a stand on the issue and supports the opinion.	The student takes a stand on the issue but does not support the opinion.	The student fails to take a stand on the issue.



Read



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Natural selection determines what variations will survive and what variations will die out. Only those organisms best adapted to the environment will survive and pass on their genetic characteristics to the next generation. Those organisms less adapted will not survive, and their traits will not be passed on. For example, the fast and fit figurines in the illustration to the left will survive the stomping attack of the giant stick man. They will be able to reproduce and pass on to their offspring the characteristics that helped

natural selection: the process that results when the characteristics of a population of organisms change because individuals with certain inherited traits survive specific local environmental conditions and, through reproduction, pass on their traits to their offspring

sexual selection: a type of natural selection where characteristics are selected based on mate preferences

them survive. In time, the characteristics of the population change due to the surviving traits. Charles Darwin developed his theory of **natural selection** to explain how populations change or evolve over time. The development and evidence supporting this theory will be discussed in more detail in Lesson 2.

Read page 118 of the textbook, starting at “Natural Selection.” Continue reading up to “Section 4.1 Summary” on page 121. You may skim over the Thought Labs.

The desire to mate is strong in all organisms, and it creates a strong selection pressure. In some cases, the mates’ selective pressure is oblivious to other environmental selection pressures. Selecting characteristics based on attracting a mate is called **sexual selection**.

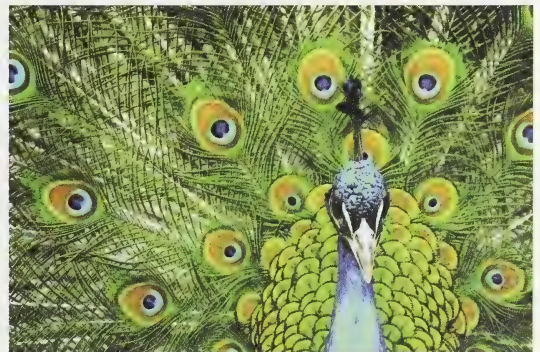


Watch and Listen

The Peacock and Natural Selection

Have you ever wondered why the peacock has evolved a beautiful, long tail? The theory of sexual selection in peacocks is explored in a video found on the PBS website. To find this video, type in the keywords “pbs evolution library peacock tale.” If this video is unavailable to you, continue searching the Internet for answers to the following question:

- Why do male peacocks have long, beautiful tails that make it more difficult to escape from predators?



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Explain your answer using images, text, or a combination of both. Your explanation could be in the form of a comic, a story, or a summary. Place this explanation in your course folder and in the Lesson 1 Assignment.

Peacock Activity Marking Rubric

	4	3	2	1
Accuracy of Explanation	The explanation is very accurate and detailed.	The explanation is accurate and detailed.	The explanation is accurate.	The explanation is inaccurate.
Clarity of Explanation	The explanation is very easy to interpret and understand.	The explanation is easy to interpret and understand.	The explanation is somewhat difficult to understand.	The explanation is difficult to understand.



Read



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Abiotic and biotic environmental conditions can exert **selective pressure** on a population by selecting for certain characteristics. These selected characteristics allow the individual to survive. In the photos above, which of the two lizards is more likely to be preyed upon?

Actually, both the iguana and the chameleon are adapted to blend into or mimic their environment. If the environment of each lizard were to change drastically, and they were no longer camouflaged, the lizards could be in greater danger than those that blend in better.

selective pressure: environmental conditions that select for certain characteristics of individuals and select against other characteristics

In the peppered moth activity, the soot darkening the forest is an example of an abiotic environmental condition exerting a selective pressure on the population of peppered moths. The agent of this selection—the blue jay—is biotic. The soot-darkened forest selected for the dark-coloured moths and against the light-

coloured moths. Therefore, the dark-coloured moth population increased and the light-coloured moth population decreased.

Selective pressure can also be exerted by a biotic component in the environment, as was observed with sexual selection. Predators are another example of a biotic component in the environment exerting a selection pressure.

Try This

TR 2. Selective Pressures

Answer the TR 2. Selective Pressures questions in your Lesson 1 Assignment in the Module 4 Assignment Booklet.

Lab: Finch Beak Depth

Environmental factors, adaptation, variation, and mutation all play a role in the struggle for survival among individuals in a population. Charles Darwin based his theories of natural selection primarily on his observations of finches in the Galapagos Islands. In this lab you will determine the effect of environmental conditions on finch beak depth.

Problem

How does the depth of finch beaks vary with periods of drought or heavy rain?

Procedure

Step 1: You will be using a simulation to explore the answer to this lab problem. Go to www.learnalberta.ca. You may be required to input a username and password. Contact your teacher for this information. Enter the search terms “Rainfall and Bird” in the search bar. Choose the item called “Rainfall and Bird Beaks (Grade 11).”

Step 2: Open and follow the steps in the Exploration Guide.

Step 3: Record your data in a table similar to the one below.

Step 4: Answer the Analysis and Conclusion questions in your Lesson 1 Assignment. Save your responses in your course folder.



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Data and Observations

Beak Depth and Finch Population Sizes for Varying Average Inches of Rainfall

Average Inches of Rainfall (inches)	Average Depth of Beak (mm)	Average Population of Finches
1		
5		
10		

Analysis

1. During what part of the year does the finch population increase? Why do you think this is so?
2. How did the number of finches change after the five years of drought? Why do you think this is so?
3. What happens to the average beak depth after the five-year drought?
4. During years of drought, the smaller, softer seeds are quickly eaten up, leaving behind only the larger, tougher seeds that are harder to crack and more difficult to find under the baked soil. What kinds of beaks are more useful in these conditions? Why? How does this information relate to your answer to question 3?
5. Assuming that beak depth is a genetic trait, and that an individual finch cannot change the shape of its own beak, how did the change in average beak depth actually occur during the drought? Explain in detail.
6. When rainfall is above average in the Galapagos Islands, a higher proportion of seeds are small. How does this explain the trend in beak size you observed after five years of excess rain?

Conclusion

1. How did the finch population size and beak depth respond to drought years? What about in years of heavy rainfall?
2. What selection pressure caused the change in beak depth? Explain.

**Reflect and Connect****Self-Check**

SC 6. Go to your Biology 20 Multimedia DVD, and complete the Self-Check exercise called “Reflect and Connect: Self-Check.”

**Reflect and Connect**

Complete **one** of the following activities. Place the finished product in your course folder.

- Create a mind map to show the connections between mutations, sexual reproduction, variation, and natural selection.
- Give a visual or text-based example or representation for each of the following:
 - sexual selection
 - biotic selective pressure
 - abiotic selective pressure
 - variation
 - natural selection
- Make two lists using text or images. The first list should include organisms with characteristics that could have evolved by sexual selection. The second list should include organisms with features that likely evolved due to natural selection where the organism's food source could have been the selective pressure.

**Reflect on the Big Picture**

You have seen the importance of variation in the survival of a species and learned how variation affects the evolution of a population. A population needs variation in order to survive environmental changes. When one organism has an advantage because of a variation, it can survive. When the organism reproduces, it passes on the adaptation to its offspring. Eventually, over time and many generations, most of the population will have this adaptation. The accumulation of adaptations causes the population to evolve.

Can you look at your own life and see examples of variation? Do any of these variations give you or your friends an advantage? Make a list of these variations, and discuss them with a friend or a classmate before you get started on your module project.

Module Project

You will create a game, play, or podcast for this project. Participants must answer a variety of questions while playing the game, watching the play, or viewing the podcast. Have you read through the requirements for the module project yet? If not, you can find the requirements in the Module Summary and Assessment. Read through the project information so you understand how you will be assessed on this major project.

1. Read through the requirements for the module project in the Module Summary and Assessment.
2. Decide on a theme. Some possible theme ideas include human evolution, extinct species, a day in the life of Charles Darwin, controversial evolution, dinosaurs, or any other theme you can think of.

3. You have learned enough information in this lesson to answer the first three questions in the assignment. Jot down notes on these three questions.
 - How is sexual reproduction significant in creating variation within populations?
 - How can mutations improve or harm an individual organism's chances for survival and reproduction?
 - How do variations lead to the evolution of populations?
4. Brainstorm ways of getting this information into your game, play, or podcast in a creative way. You may work in partners to complete this assignment. You may like to brainstorm with another student even if you are not working together.
5. Place your work in progress in your course folder. You will revisit this work in Lesson 2.



Going Beyond

Choose one of the following two activities to complete.

- How does natural selection explain the development of the human eye? What type of evidence do scientists have that this theory might be correct? The PBS website contains content that specifically discusses the eye, and it contains a link to a video that helps explain how natural selection may have created the eye. Use an Internet search engine to find this site by typing in the keywords “pbs evolution library.” Once at this site, you can search for “evolution of the eye.” Put your answers in your course folder.
- Read the following chapter from Darwin's book called “The Origin of Species.” In “Chapter 4: Natural Selection,” Darwin discusses sexual selection and gives some examples of natural selection. You may find the language difficult but, at the same time, interesting. Take an example of natural or sexual selection from this chapter and, in your own words, add it to your portfolio.

Excerpt from *The Origin of Species*, by Charles Darwin

Chapter 4: Natural Selection

How will the struggle for existence, discussed too briefly in the last chapter, act in regard to variation? Can the principle of selection, which we have seen is so potent in the hands of man, apply in nature? I think we shall see that it can act most effectually. Let it be borne in mind in what an endless number of strange peculiarities our domestic productions, and, in a lesser degree, those under nature, vary; and how strong the hereditary tendency is. Under domestication, it may be truly said that the whole organisation becomes in some degree plastic. Let it be borne in mind how infinitely complex and close-fitting are the mutual relations of all organic beings to each other and to their physical conditions of life. Can it, then, be thought improbable, seeing that variations useful to man have undoubtedly occurred, that other variations useful in some way to each being in the great and complex battle of life, should sometimes occur in the course of thousands of generations? If such do occur, can we doubt (remembering that many more individuals are born than can possibly survive) that individuals having any advantage, however slight, over others, would have the best chance of surviving and of procreating their kind? On the other hand, we may feel sure that any variation in the least degree injurious would be rigidly destroyed. This preservation of favourable variations and the rejection of injurious variations, I call Natural Selection. Variations neither useful nor injurious would not be affected by natural selection, and would be left a fluctuating element, as perhaps we see in the species called polymorphic.

We have reason to believe, as stated in the first chapter, that a change in the conditions of life, by specially acting on the reproductive system, causes or increases variability; and in the foregoing case the conditions of life are supposed to have undergone a change, and this would manifestly be favourable to natural selection, by giving a better chance of profitable variations occurring; and unless profitable variations do occur, natural selection can do nothing. Not that, as I believe, any extreme amount of variability is necessary; as man can certainly produce great results by adding up in any given direction mere individual differences, so could Nature, but far more easily, from having incomparably longer time at her disposal. Nor do I believe that any great physical change, as of climate, or any unusual degree of isolation to check immigration, is actually necessary to produce new and unoccupied places for natural selection to fill up by modifying and improving some of the varying inhabitants. For as all the inhabitants of each country are struggling together with nicely balanced forces, extremely slight modifications in the structure or habits of one inhabitant would often give it an advantage over others; and still further modifications of the same kind would often still further increase the advantage. No country can be named in which all the native inhabitants are now so perfectly adapted to each other and to the physical conditions under which they live, that none of them could anyhow be improved; for in all countries, the natives have been so far conquered by naturalised productions, that they have allowed foreigners to take firm possession of the land. And as foreigners have thus everywhere beaten some of the natives, we may safely conclude that the natives might have been modified with advantage, so as to have better resisted such intruders.

It may be said that natural selection is daily and hourly scrutinising, throughout the world, every variation, even the slightest; rejecting that which is bad, preserving and adding up all that is good; silently and insensibly working, whenever and wherever opportunity offers, at the improvement of each organic being in relation to its organic and inorganic conditions of life. We see nothing of these slow changes in progress, until the hand of time has marked the long lapses of ages, and then so imperfect is our view into long past geological ages, that we only see that the forms of life are now different from what they formerly were.

Although natural selection can act only through and for the good of each being, yet characters and structures, which we are apt to consider as of very trifling importance, may thus be acted on. When we see leaf-eating insects green, and bark-feeders mottled-grey; the alpine ptarmigan white in winter, the red-grouse the colour of heather, and the black-grouse that of peaty earth, we must believe that these tints are of service to these birds and insects in preserving them from danger. Grouse, if not destroyed at some period of their lives, would increase in countless numbers; they are known to suffer largely from birds of prey; and hawks are guided by eyesight to their prey, so much so, that on parts of the Continent persons are warned not to keep white pigeons, as being the most liable to destruction. Hence I can see no reason to doubt that natural selection might be most effective in giving the proper colour to each kind of grouse, and in keeping that colour, when once acquired, true and constant. Nor ought we to think that the occasional destruction of an animal of any particular colour would produce little effect: we should remember how essential it is in a flock of white sheep to destroy every lamb with the faintest trace of black. In plants the down on the fruit and the colour of the flesh are considered by botanists as characters of the most trifling importance: yet we hear from an excellent horticulturist, Downing, that in the United States smooth-skinned fruits suffer far more from a beetle, a *curculio*, than those with down; that purple plums suffer far more from a certain disease than yellow plums; whereas another disease attacks yellow-fleshed peaches far more than those with other coloured flesh. If, with all the aids of art, these slight differences make a great difference in cultivating the several varieties, assuredly, in a state of nature, where the trees would have to struggle with other trees and with a host of enemies, such differences would effectually settle which variety, whether a smooth or downy, a yellow or purple fleshed fruit, should succeed.

In looking at many small points of difference between species, which, as far as our ignorance permits us to judge, seem to be quite unimportant, we must not forget that climate, food, &c., probably produce some slight and direct effect. It is, however, far more necessary to bear in mind that there are many unknown laws of correlation of growth, which, when one part of the organisation is modified through variation, and the modifications are accumulated by natural selection for the good of the being, will cause other modifications, often of the most unexpected nature.

Natural selection will modify the structure of the young in relation to the parent, and of the parent in relation to the young. In social animals it will adapt the structure of each individual for the benefit of the community; if each in consequence profits by the selected change. What natural selection cannot do, is to modify the structure of one species, without giving it any advantage, for the good of another species; and though statements to this effect may be found in works of natural history, I cannot find one case which will bear investigation. A structure used only once in an animal's whole life, if of high importance to it, might be modified to any extent by natural selection; for instance, the great jaws possessed by certain insects, and used exclusively for opening the cocoon or the hard tip to the beak of nestling birds, used for breaking the egg. It has been asserted, that of the best short-beaked tumbler-pigeons more perish in the egg than are able to get out of it; so that fanciers assist in the act of hatching. Now, if nature had to make the beak of a full-grown pigeon very short for the bird's own advantage, the process of modification would be very slow, and there would be simultaneously the most rigorous selection of the young birds within the egg, which had the most powerful and hardest beaks, for all with weak beaks would inevitably perish: or, more delicate and more easily broken shells might be selected, the thickness of the shell being known to vary like every other structure.

Sexual Selection

Inasmuch as peculiarities often appear under domestication in one sex and become hereditarily attached to that sex, the same fact probably occurs under nature, and if so, natural selection will be able to modify one sex in its functional relations to the other sex, or in relation to wholly different habits of life in the two sexes, as is

sometimes the case with insects. And this leads me to say a few words on what I call Sexual Selection. This depends, not on a struggle for existence, but on a struggle between the males for possession of the females; the result is not death to the unsuccessful competitor, but few or no offspring. Sexual selection is, therefore, less rigorous than natural selection. Generally, the most vigorous males, those which are best fitted for their places in nature, will leave most progeny. But in many cases, victory will depend not on general vigour, but on having special weapons, confined to the male sex. A hornless stag or spurless cock would have a poor chance of leaving offspring. Sexual selection by always allowing the victor to breed might surely give indomitable courage, length to the spur, and strength to the wing to strike in the spurred leg, as well as the brutal cock-fighter, who knows well that he can improve his breed by careful selection of the best cocks. How low in the scale of nature this law of battle descends, I know not; male alligators have been described as fighting, bellowing, and whirling round, like Indians in a war-dance, for the possession of the females; male salmon have been seen fighting all day long; male stag-beetles often bear wounds from the huge mandibles of other males. The war is, perhaps, severest between the males of polygamous animals, and these seem oftenest provided with special weapons. The males of carnivorous animals are already well armed; though to them and to others, special means of defence may be given through means of sexual selection, as the mane to the lion, the shoulder-pad to the boar, and the hooked jaw to the male salmon; for the shield may be as important for victory, as the sword or spear.

Thus it is, as I believe, that when the males and females of any animal have the same general habits of life, but differ in structure, colour, or ornament, such differences have been mainly caused by sexual selection; that is, individual males have had, in successive generations, some slight advantage over other males, in their weapons, means of defence, or charms; and have transmitted these advantages to their male offspring. Yet, I would not wish to attribute all such sexual differences to this agency: for we see peculiarities arising and becoming attached to the male sex in our domestic animals (as the wattle in male carriers, horn-like protuberances in the cocks of certain fowls, &c.), which we cannot believe to be either useful to the males in battle, or attractive to the females. We see analogous cases under nature, for instance, the tuft of hair on the breast of the turkey-cock, which can hardly be either useful or ornamental to this bird; indeed, had the tuft appeared under domestication, it would have been called a monstrosity.

Illustrations of the action of Natural Selection

In order to make it clear how, as I believe, natural selection acts, I must beg permission to give one or two imaginary illustrations. Let us take the case of a wolf, which preys on various animals, securing some by craft, some by strength, and some by fleetness; and let us suppose that the fleetest prey, a deer for instance, had from any change in the country increased in numbers, or that other prey had decreased in numbers, during that season of the year when the wolf is hardest pressed for food. I can under such circumstances see no reason to doubt that the swiftest and slimmest wolves would have the best chance of surviving, and so be preserved or selected, provided always that they retained strength to master their prey at this or at some other period of the year, when they might be compelled to prey on other animals. I can see no more reason to doubt this, than that man can improve the fleetness of his greyhounds by careful and methodical selection, or by that unconscious selection which results from each man trying to keep the best dogs without any thought of modifying the breed.

Even without any change in the proportional numbers of the animals on which our wolf preyed, a cub might be born with an innate tendency to pursue certain kinds of prey. Nor can this be thought very improbable; for we often observe great differences in the natural tendencies of our domestic animals; one cat, for instance, taking to catch rats, another mice; one cat, according to Mr. St. John, bringing home winged game, another hares or rabbits, and another hunting on marshy ground and almost nightly catching woodcocks or snipes. The

tendency to catch rats rather than mice is known to be inherited. Now, if any slight innate change of habit or of structure benefited an individual wolf, it would have the best chance of surviving and of leaving offspring. Some of its young would probably inherit the same habits or structure, and by the repetition of this process, a new variety might be formed which would either supplant or coexist with the parent-form of wolf. Or, again, the wolves inhabiting a mountainous district, and those frequenting the lowlands, would naturally be forced to hunt different prey; and from the continued preservation of the individuals best fitted for the two sites, two varieties might slowly be formed. These varieties would cross and blend where they met; but to this subject of intercrossing we shall soon have to return. I may add, that, according to Mr. Pierce, there are two varieties of the wolf inhabiting the Catskill Mountains in the United States, one with a light greyhound-like form, which pursues deer, and the other more bulky, with shorter legs, which more frequently attacks the shepherd's flocks.

Let us now take a more complex case. Certain plants excrete a sweet juice, apparently for the sake of eliminating something injurious from their sap: this is effected by glands at the base of the stipules in some Leguminosae, and at the back of the leaf of the common laurel. This juice, though small in quantity, is greedily sought by insects. Let us now suppose a little sweet juice or nectar to be excreted by the inner bases of the petals of a flower. In this case insects in seeking the nectar would get dusted with pollen, and would certainly often transport the pollen from one flower to the stigma of another flower. The flowers of two distinct individuals of the same species would thus get crossed; and the act of crossing, we have good reason to believe (as will hereafter be more fully alluded to), would produce very vigorous seedlings, which consequently would have the best chance of flourishing and surviving. Some of these seedlings would probably inherit the nectar-excreting power. Those in individual flowers which had the largest glands or nectaries, and which excreted most nectar, would be oftenest visited by insects, and would be oftenest crossed; and so in the long-run would gain the upper hand. Those flowers, also, which had their stamens and pistils placed, in relation to the size and habits of the particular insects which visited them, so as to favour in any degree the transportal of their pollen from flower to flower, would likewise be favoured or selected. We might have taken the case of insects visiting flowers for the sake of collecting pollen instead of nectar; and as pollen is formed for the sole object of fertilisation, its destruction appears a simple loss to the plant; yet if a little pollen were carried, at first occasionally and then habitually, by the pollen-devouring insects from flower to flower, and a cross thus effected, although nine-tenths of the pollen were destroyed, it might still be a great gain to the plant; and those individuals which produced more and more pollen, and had larger and larger anthers, would be selected.

When our plant, by this process of the continued preservation or natural selection of more and more attractive flowers, had been rendered highly attractive to insects, they would, unintentionally on their part, regularly carry pollen from flower to flower; and that they can most effectually do this, I could easily show by many striking instances. I will give only one not as a very striking case, but as likewise illustrating one step in the separation of the sexes of plants, presently to be alluded to. Some holly-trees bear only male flowers, which have four stamens producing rather a small quantity of pollen, and a rudimentary pistil; other holly-trees bear only female flowers; these have a full-sized pistil, and four stamens with shrivelled anthers, in which not a grain of pollen can be detected. Having found a female tree exactly sixty yards from a male tree, I put the stigmas of twenty flowers, taken from different branches, under the microscope, and on all, without exception, there were pollen-grains, and on some a profusion of pollen. As the wind had set for several days from the female to the male tree, the pollen could not thus have been carried. The weather had been cold and boisterous, and therefore not favourable to bees, nevertheless every female flower which I examined had been effectually fertilised by the bees, accidentally dusted with pollen, having flown from tree to tree in search of nectar. But to return to our imaginary case: as soon as the plant had been rendered so highly attractive to insects that pollen was regularly carried from flower to flower, another process might commence. No naturalist doubts the advantage of what has been called the 'physiological division of labour;' hence we may believe that it would be

advantageous to a plant to produce stamens alone in one flower or on one whole plant, and pistils alone in another flower or on another plant. In plants under culture and placed under new conditions of life, sometimes the male organs and sometimes the female organs become more or less impotent; now if we suppose this to occur in ever so slight a degree under nature, then as pollen is already carried regularly from flower to flower, and as a more complete separation of the sexes of our plant would be advantageous on the principle of the division of labour, individuals with this tendency more and more increased, would be continually favoured or selected, until at last a complete separation of the sexes would be effected.

I am well aware that this doctrine of natural selection, exemplified in the above imaginary instances, is open to the same objections which were at first urged against Sir Charles Lyell's noble views on 'the modern changes of the earth, as illustrative of geology;' but we now very seldom hear the action, for instance, of the coast-waves, called a trifling and insignificant cause, when applied to the excavation of gigantic valleys or to the formation of the longest lines of inland cliffs. Natural selection can act only by the preservation and accumulation of infinitesimally small inherited modifications, each profitable to the preserved being; and as modern geology has almost banished such views as the excavation of a great valley by a single diluvial wave, so will natural selection, if it be a true principle, banish the belief of the continued creation of new organic beings, or of any great and sudden modification in their structure.

Summary of Chapter

If during the long course of ages and under varying conditions of life, organic beings vary at all in the several parts of their organisation, and I think this cannot be disputed; if there be, owing to the high geometrical powers of increase of each species, at some age, season, or year, a severe struggle for life, and this certainly cannot be disputed; then, considering the infinite complexity of the relations of all organic beings to each other and to their conditions of existence, causing an infinite diversity in structure, constitution, and habits, to be advantageous to them, I think it would be a most extraordinary fact if no variation ever had occurred useful to each being's own welfare, in the same way as so many variations have occurred useful to man. But if variations useful to any organic being do occur, assuredly individuals thus characterised will have the best chance of being preserved in the struggle for life; and from the strong principle of inheritance they will tend to produce offspring similarly characterised. This principle of preservation, I have called, for the sake of brevity, Natural Selection. Natural selection, on the principle of qualities being inherited at corresponding ages, can modify the egg, seed, or young, as easily as the adult. Amongst many animals, sexual selection will give its aid to ordinary selection, by assuring to the most vigorous and best adapted males the greatest number of offspring. Sexual selection will also give characters useful to the males alone, in their struggles with other males.

Whether natural selection has really thus acted in nature, in modifying and adapting the various forms of life to their several conditions and stations, must be judged of by the general tenour and balance of evidence given in the following chapters. But we already see how it entails extinction; and how largely extinction has acted in the world's history, geology plainly declares. Natural selection, also, leads to divergence of character; for more living beings can be supported on the same area the more they diverge in structure, habits, and constitution, of which we see proof by looking at the inhabitants of any small spot or at naturalised productions. Therefore during the modification of the descendants of any one species, and during the incessant struggle of all species to increase in numbers, the more diversified these descendants become, the better will be their chance of succeeding in the battle of life. Thus the small differences distinguishing varieties of the same species, will steadily tend to increase till they come to equal the greater differences between species of the same genus, or even of distinct genera.

We have seen that it is the common, the widely-diffused, and widely-ranging species, belonging to the larger genera, which vary most; and these will tend to transmit to their modified offspring that superiority which now makes them dominant in their own countries. Natural selection, as has just been remarked, leads to divergence of character and to much extinction of the less improved and intermediate forms of life. On these principles, I believe, the nature of the affinities of all organic beings may be explained. It is a truly wonderful fact the wonder of which we are apt to overlook from familiarity that all animals and all plants throughout all time and space should be related to each other in group subordinate to group, in the manner which we everywhere behold namely, varieties of the same species most closely related together, species of the same genus less closely and unequally related together, forming sections and sub-genera, species of distinct genera much less closely related, and genera related in different degrees, forming sub-families, families, orders, sub-classes, and classes. The several subordinate groups in any class cannot be ranked in a single file, but seem rather to be clustered round points, and these round other points, and so on in almost endless cycles. On the view that each species has been independently created, I can see no explanation of this great fact in the classification of all organic beings; but, to the best of my judgment, it is explained through inheritance and the complex action of natural selection, entailing extinction and divergence of character, as we have seen illustrated in the diagram.

The affinities of all the beings of the same class have sometimes been represented by a great tree. I believe this simile largely speaks the truth. The green and budding twigs may represent existing species; and those produced during each former year may represent the long succession of extinct species. At each period of growth all the growing twigs have tried to branch out on all sides, and to overtop and kill the surrounding twigs and branches, in the same manner as species and groups of species have tried to overmaster other species in the great battle for life. The limbs divided into great branches, and these into lesser and lesser branches, were themselves once, when the tree was small, budding twigs; and this connexion of the former and present buds by ramifying branches may well represent the classification of all extinct and living species in groups subordinate to groups. Of the many twigs which flourished when the tree was a mere bush, only two or three, now grown into great branches, yet survive and bear all the other branches; so with the species which lived during long-past geological periods, very few now have living and modified descendants. From the first growth of the tree, many a limb and branch has decayed and dropped off; and these lost branches of various sizes may represent those whole orders, families, and genera which have now no living representatives, and which are known to us only from having been found in a fossil state. As we here and there see a thin straggling branch springing from a fork low down in a tree, and which by some chance has been favoured and is still alive on its summit, so we occasionally see an animal like the *Ornithorhynchus* or *Lepidosiren*, which in some small degree connects by its affinities two large branches of life, and which has apparently been saved from fatal competition by having inhabited a protected station. As buds give rise by growth to fresh buds, and these, if vigorous, branch out and overtop on all sides many a feebler branch, so by generation I believe it has been with the great Tree of Life, which fills with its dead and broken branches the crust of the earth, and covers the surface with its ever branching and beautiful ramifications.



Module 4: Lesson 1 Assignment

Make sure you have completed all of the questions for the Lesson 1 Assignment. Check with your teacher about whether you should submit your assignment now or wait until all of the Module 4 assignments have been completed.



Lesson Summary

In this lesson you explored the following essential questions:

- How do mutations create species variability?
- Why is sexual reproduction important to the process of evolution?

Soccer takes balance, timing, speed, and agility. Some of these characteristics are passed on from one generation to the next, and some are not. Some people will be good soccer players, some people will get better with practice, and other people will just never be fast enough to keep up with the others.

In this lesson you have learned that variations are created by mutations and sexual reproduction. Variations that allow organisms to survive in their environment are called adaptations. These adaptations will then be passed on to the next generation. Over time, these variations will change characteristics in a population and lead to the evolution of populations.

In Lesson 2 you will explore two theories to help understand how evolution occurs.

Lesson Glossary

adaptation: a beneficial variation that helps an organism survive

mutagen: something that causes an increased rate of mutation

mutation: a change in the genetic material of an organism (DNA)

natural selection: the process that results when the characteristics of a population of organisms change because individuals with certain inherited traits survive specific local environmental conditions and, through reproduction, pass on their traits to their offspring

selective advantage: an organism's variations increase its chances of surviving

selective disadvantage: an organism's variations reduce its chances of surviving

selective pressure: environmental conditions that select for certain characteristics of individuals and select against other characteristics

sexual selection: a type of natural selection where characteristics are selected based on mate preferences

variation: visible or invisible differences between individuals

Lesson 2—Developing Theories to Explain Change



Get Focused

If your parents and friends had to explain why your taste in music evolved from punk rock in January to classical jazz in September, they would have to make a theory based on their observations. Since your parents like classical jazz, perhaps they think your taste in music came from them. Meanwhile, your friends may observe that you lost your punk rock collection and had to resort to listening to whatever music your parents had. Which theory do you think best explains your situation?

Evolutionary scientists, such as Charles Darwin and Jean Baptiste Lamarck, used their observations to explain the phenomenon of evolution. What scientist ended up making the correct conclusions?

In this lesson you will explore the following essential questions:

- How do theories explaining evolutionary change compare?
- What theories attempt to explain the pace of evolutionary change?



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Module 4: Lesson 2 Assignment

In this lesson you will complete the Lesson 2 Assignment in the Module 4 Assignment Booklet.

- TR 2. Answering Darwin's Questions
- TR 3. The Pace of Evolution
- Reflect and Connect: Applying and Comparing Theories of Evolution

You must decide what to do with the questions that are not marked by the teacher.

Remember that these questions provide you with the practice and feedback that you need to successfully complete this course. You should respond to all the questions and place those answers in your course folder.



Explore



Read

Scientists, Hypotheses, and Theories

By reading pages 122 to 124 in your textbook, you will see how scientific knowledge is accumulated, organized, and used to develop hypotheses and theories. **Hypotheses** are tested over time and are accepted or rejected. When a hypothesis consistently predicts and correctly explains observations, a scientific theory will eventually develop.

hypothesis: a statement that provides one possible answer to a question or one possible explanation for an observation



Try This

TR 1. Scientists, Hypotheses, and Theories

Use a table to record what you learned about each scientist from the reading.

Scientist	Major Observation(s)
Buffon (1707–1788)	
Cuvier (1769–1832)	
Lyell (1797–1875)	
Lamarck (1744–1829)	
Wallace (1823–1913)	
Darwin (1809–1882)	

Store the results in your course folder for a later review and study.



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As you read on page 122 of the textbook, Georges Cuvier was a naturalist who developed the science of **paleontology**. He studied **fossils** and made predictions about life in the past. He proposed the idea that Earth had experienced many destructive natural events, such as floods and volcanic eruptions. Cuvier proposed that these events were violent enough to have eliminated many species.

paleontology: the study of ancient life through the examination of fossils

fossils: the remains of past life found in sedimentary rock



Self-Check

SC 1. A geologist finds the fossil of a species of fish in one stratum, but not in the stratum above the fossil. How do you think Cuvier would explain this observation?

Check your work with the answer in the appendix.

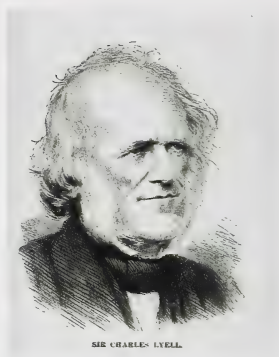
Charles Lyell was a geologist who rejected Cuvier's ideas of violent events killing species. Lyell believed that geological processes operated at the same rate in the past as they do today. The geologist also estimated the age of Earth to be more than 6000 years.

SC 2. How did Lyell's observations about changes in geology inspire naturalists to think about changes in life on Earth?

Check your work with the answer in the appendix.

SC 3. Science is a process, and much shared knowledge led up to Darwin's theory of evolution. Using the information from pages 122 to 124 of the textbook, as well as some previous knowledge from Unit A of Biology 20, complete the following science knowledge timeline.

Go to your Biology 20 Multimedia DVD, and complete the timeline called "Geological Time Scale."



SIR CHARLES LYELL





Read

Darwin's Evidence

Darwin travelled from England to South America to Australia and back to South America during his five-year voyage aboard the HMS Beagle. Observations he made in England and while exploring caused Darwin to ask many questions about the natural world. Read about Darwin's observations and the questions that arose from them on pages 125 and 126 in the textbook. Read up to the heading "Further Evidence of Evolution" on page 126.



Try This

TR 2. Answering Darwin's Questions

Darwin used the answers to questions based on his observations to formulate his theory of natural selection. Go to your Lesson 2 Assignment in your Module 4 Assignment Booklet to answer some of Darwin's questions.



Watch and Listen

A lecture from the Howard Hughes Medical Institute, titled "Endless Forms Most Beautiful," discusses Darwin's life (his father worried he wouldn't have a respectable profession) and how he developed his theory of evolution by natural selection. It is a lecture for high school students. The lecture reviews mutations, variations, and how natural selection works. The lecture is about an hour long and is very informative and interesting. You may prefer to watch this at two separate times.



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In order to find this video, you need to do a web search. It is easy to find if you type in the keywords "endless forms most beautiful evolution lecture." Scroll down the page about halfway to find the link for the video lecture. In your web search you may also find summaries of the book titled "Endless Forms Most Beautiful," written by the lecturer Dr. Sean Carroll. Reading these summaries may also help you understand the lecture.

This lecture is an excellent summary of much of what you will learn about Charles Darwin and his theories.



Self-Check

S4. Go to your Biology 20 Multimedia DVD, and complete the Self-Check called "Endless Forms Most Beautiful Self-Check." Complete this exercise after you have accessed the "Endless Forms Most Beautiful" lecture. Even if you did not explore this lecture in great depth, you will be able to answer some of the questions in this Self-Check based on your readings so far.

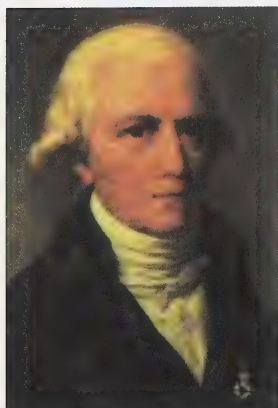


Watch and Listen

The following animation reviews Darwin's theory of evolution and natural selection. Go to your Biology 20 Multimedia DVD, and watch the animation called "Darwin's Theory of Evolution and Natural Selection" to discover the theory behind evolution by natural selection.



Read



In the same year Charles Darwin was born, Jean-Baptiste Lamarck published his theory about how species change over time. Lamarck compared fossils with current species and noticed a progression of changes from the fossil structures to the current species. He believed that species have been increasing in complexity over time in order to achieve a level of perfection. Lamarck proposed that organisms could pass on developed characteristics (for example, big muscles from working out) by the **inheritance of acquired characteristics**.

inheritance of acquired characteristics: the theory that characteristics acquired during an organism's lifetime could be passed to its offspring



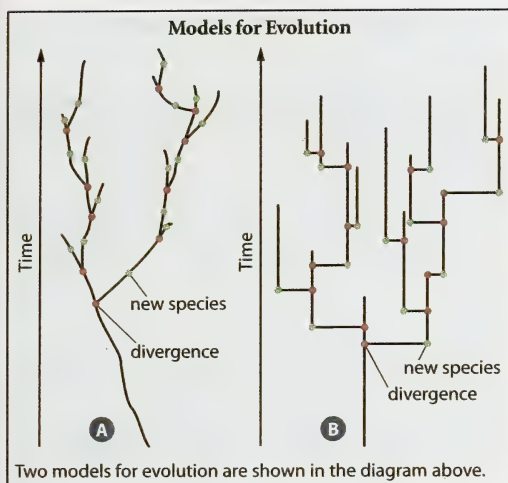
Watch and Listen

Comparing Theories

Go to your Biology 20 Multimedia DVD, and watch the presentation called "Lamarck's Theory of Evolution vs. Darwin's Theory of Evolution." This animated presentation compares the theories of evolution by Lamarck and Darwin. Make note of the similarities and differences between these theories.



Read



Darwin's theory of evolution by natural selection remains the basis of many people's understanding of evolution. However, scientific debate about the pace of evolution continues. Modern-day scientists propose two models: **gradualism** and **punctuated equilibrium**. Read "The Pace of Evolution" on page 140 in the textbook.

gradualism: gradual change occurs in a steady, linear way over time

punctuated equilibrium: evolutionary history is said to consist of long periods of equilibrium, interrupted by periods of speciation

Inquiry into Biology u2_p.150, from McGraw Hill Reproduced by permission.



Try This

TR 3. The Pace of Evolution

You will look at which theory—in your opinion—best explains evolution. You will also compare and contrast gradualism with punctuated equilibrium. Go to your Lesson 2 Assignment in your Module 4 Assignment Booklet to answer the questions for this Try This activity.



Reflect and Connect

Applying and Comparing Theories of Evolution

This Reflect and Connect activity allows you to compare and apply the theories of Darwin and Lamarck. Go to your Lesson 2 Assignment in your Module 4 Assignment Booklet to complete this activity.



Reflect on the Big Picture

You have now been introduced to some of the scientists who shaped Darwin's thinking. Darwin knew about Lamarck's theory of evolution when he came up with his own theory of evolution and natural selection. You need to incorporate this new information into your Module Project.

Project Hint

- If you are creating a game, perhaps "Natural Selection" could be a space you land on. If you have an adaptation, you can survive and reproduce (roll again or gain players). If a player enters a new environment on the game board (for example, a swamp), he or she may not be well-adapted (lose a turn or lose life points).
- If you are writing a play or a podcast, you could have Darwin and Lamarck as arm-wrestling characters who are discussing their beliefs.

These are only examples of how to incorporate the information from Lesson 2 into your Module Project. You may use the given examples or come up with your own ideas. Discuss some creative ideas for your project.

Continue working on your Module Project.

1. You should now have enough information to answer question 4. Jot down notes to answer the question "How do the Lamarckian and Darwinian explanations of evolutionary change compare?"
2. Brainstorm ways that this information could be in your game, play, or podcast.
3. Look back at the project work you placed in your course folder in Lesson 1.
4. Begin creating your game rules/setup or the plot outline for your play.

Place what you have completed in your Biology 20 course folder. You will continue working on this project in Lesson 3.



Module 4: Lesson 2 Assignment

Make sure you have completed all of the questions for the Lesson 2 Assignment. Check with your teacher about whether you should submit your assignment now or wait until all of the Module 4 assignments have been completed.



Lesson Summary

In this lesson you explored the following essential questions:

- How do theories explaining evolutionary change compare?
- What theories attempt to explain the pace of evolutionary change?

In this lesson you examined theories that led Charles Darwin and Jean-Baptiste Lamarck to create their own theories about evolution. Both scientists believed that organisms with beneficial adaptations to the environment would survive.

The difference between the theories is how these organisms obtained their adaptations. Lamarck believed organisms could acquire their adaptations during their lifetimes, whereas Darwin thought that organisms were born with traits, which were then selected by nature. Over time, Darwin proposed that these beneficial traits would build up in a population, causing the population to change or evolve.

In Lamarck's view, evolution occurs within a single generation or within a few generations. Darwin's view suggests that evolution occurs over many generations and a long period of time. Many modern scientists accept Darwin's theory of evolution by natural selection to be true. However, there is debate about the pace of evolution. Does evolution happen gradually or in punctuated bursts of divergence?

As you learn more about evolution, you will find that it is still an evolving topic in science. The discovery of new species and a risk of the loss of other species continues to keep people thinking about evolution as changes in climate and the development of natural habitats take place. In Lesson 3 you will look at the evidence scientists use to prove evolution has occurred and the evidence they use to study evolutionary relationships.

Lesson Glossary

hypothesis: a statement that provides one possible answer to a question or one possible explanation for an observation

inheritance of acquired characteristics: the theory that characteristics acquired during an organism's lifetime could be passed to its offspring

fossils: the remains of past life found in sedimentary rock

paleontology: the study of ancient life through the examination of fossils

gradualism: gradual change occurs in a steady, linear way over time

punctuated equilibrium: evolutionary history is said to consist of long periods of equilibrium, interrupted by periods of speciation

Lesson 3—Evidence for Evolution



Get Focused



Helene Colbourne et al, *Inquiry into Biology* (Toronto: McGraw-Hill Ryerson, 2007), fig. 4.9A p. 127. Reproduced by permission. (left) Courtesy of Todd Radenbaugh (right)

The images you have just looked at are of the Burgess Shale in Yoho National Park. The image on the left shows a creature from over 505 million years ago, during the Cambrian Period. The image on the right is from Yoho National Park today.

In Lesson 2 you learned about Darwin's theory of natural selection, and you can use that theory to explain why some organisms survive and others do not. What proof do you have that natural selection is a usable theory? Fossils, like the ones in the Burgess Shale, can show that organisms have changed over time or have evolved. What other evidence is used by scientists to support and study evolution?

In this lesson you will explore the following essential question:

- What proof is there that present-day species evolved from ancestral forms?



Module 4: Lesson 3 Assignment

In this lesson you will complete the Lesson 3 Assignment in the Module 4 Assignment Booklet.

- Reflect and Connect



Explore



Read

A variety of evidence for evolution exists. This includes the following:

- fossils
- anatomy
- embryology
- biogeography
- molecular biology and genetics

As you work through Lesson 3, each of the noted areas of evidence will be explained and explored in detail. Begin by watching the following animation as an introduction to the different types of evidence that exists for evolution.



Watch and Listen

The following animation is the first of several that will appear throughout this lesson. Each one looks at a piece of evidence that supports Darwin's theory of evolution. The first animation deals with fossils and supports what you will read here and in the textbook. Go to your Biology 20 Multimedia DVD, and watch the animation called "Evidence for Evolution."



Read

Evidence for Evolution—Fossils

You have probably seen fossils like the ones in this photo. They are trilobites, and these organisms don't exist today. Trilobite fossils can be found in Alberta and all over the world. Trilobites became extinct about 245 million years ago, but at one time there were more than 17 000 different species of them. The closest living relative to trilobites is likely the horseshoe crab.



© Ismael Montero / Dreamstime



© Jessica Fitzel/Dreamstime

Fossils appear in chronological order in the rock layers, or **strata**. Studying the order of the fossils can help determine their age. The order of the fossils can also help scientists organize evolutionary family trees. Fossils can help show the evolutionary lines between ancestors and living species.

strata: a layer of rock or soil that has a consistent character and is different from layers above and below it

Go to your Biology 20 Multimedia DVD, and watch the animated image called "Fossil Image." This image shows how fossils in the different strata layers can give valuable information to scientists.

Read the sections titled “The Fossil Record” and “Transitional Fossils” in the textbook, starting on page 126 and continuing to page 130. One example of a **transitional fossil** discussed in the textbook is *Archaeopteryx*. Go to your Biology 20 Multimedia DVD, and watch the animation called “Evidence for Evolution 2.”

transitional fossil: the remains or impression of a prehistoric organism that shows intermediary links between groups of organisms and shares characteristics common to these groups



Self-Check

SC 1. Why is *Archaeopteryx* considered a transitional fossil?

Check your work with the answer in the appendix.



Try This

Many movies portray prehistoric cave dwellers and dinosaurs living together. Was this really possible? Did birds evolve before or after fish? Use “Figure 4.10” on page 128 of the textbook to answer these questions. Study the geological time scale, and then try to complete the puzzle that follows.

Go to your Biology 20 Multimedia DVD, and complete the timeline called “Geological Time Scale.”



A common misconception is that humans and dinosaurs lived on Earth at the same time. Humans actually evolved over 55 million years after the dinosaurs became extinct! Dinosaurs fascinate children and adults alike. It is hard to imagine such different creatures roaming Earth.



Read

Evidence for Evolution—Patterns of Distribution

Biogeography is the study of the past and present geographical distribution of organisms. At one time, all of the continents were linked together and referred to as Pangaea. The movement of the continental plates helps to predict when and where animals evolved. Go to your Biology 20 Multimedia DVD, and watch the animation called “Evidence for Evolution 3.” View this information, and then read “Patterns of Distribution” on page 130 in the textbook.

biogeography: the study of the past and present geographical distribution of species



Self-Check

- SC 2. How many million years ago did South America and Africa break apart?
- SC 3. When did India become part of Asia?
- SC 4. Why are similar fossils of the reptile *Cynognathus* found in Africa and South America?
- SC 5. Why are there no polar bears in Antarctica or penguins at the North Pole?

Check your work with the answer in the appendix.

Evidence for Evolution—Anatomy



Read

Read “Anatomy” on pages 130 to 132 of the textbook. **Homologous** and **analogous structures** are discussed. Go to your Biology 20 Multimedia DVD, and watch the animation called “Evidence for Evolution 4,” which supports these definitions.

homologous structures: body parts in different species that have the same evolutionary origins and structural elements but may have different functions

analogous structures: body parts in different species that have similar functions but evolved separately



Self-Check

- SC 6. Are the wings shown in the next photos examples of homologous structures or analogous structures?



© Susinder / Dreamstime (bat)
© Manfredxy / Dreamstime (moth)

Check your work with the answer in the appendix.

**Watch And Listen**

Go to your Biology 20 Multimedia DVD, and watch the animation called “Evidence for Evolution 5.” You may choose to view this animation before you read up on embryology in the textbook. The graphic is a useful media support for the concepts presented here and in the textbook.

**Read****Evidence for Evolution—Embryology**

The embryos of different organisms have similar stages of development. It is not surprising that two closely related organisms are similar in both anatomy and development. The more closely related a species is to another species, the more similar the embryonic development. Read “Embryology” on page 132 in the textbook.

Evidence for Evolution—Molecular Biology and Genetics

Similarities between different species of DNA and protein structure indicate how closely related species are. Read “Molecular Biology” and “Genetics” on pages 132 and 133 in your textbook.

**Watch and Listen**

Go to your Biology 20 Multimedia DVD, and watch the animation called “Evidence for Evolution 6.” This multimedia segment supports the information given in the textbook about molecular biology and genetics.

**Reflect and Connect**

A student is on holiday and will be away for Lesson 3. Create a summary for the student so he or she can quickly catch up without missing important information. The summary can be visual, text-based, or a combination of the two. Your review may be in audio form, written, electronic, or video. It should review all the evidence for evolution learned about this lesson.

This is a part of your Lesson 3 Assignment. You will also be able to use this summary in the future as a reference and to help you study.

**Reflect on the Big Picture****Module Project**

You have now explored different types of evidence for evolution. Now you can build this new knowledge into your game, play, or podcast. Maybe you want game players to collect bones as they travel around the board, as they build a fossil skeleton, or as they find a transitional fossil.

Will your players be quizzed on analogous structures? Or maybe they need to collect pieces of DNA to compare evolutionary lineages. Will your play include props? Maybe a fossil skeleton would create an interesting dialogue about evolution. Imagine what Darwin would say today had he known about genetics and DNA!

You may use all, some, or none of the noted ideas from the first three lessons in your Module Project, but it is now time to continue working on it.

1. You should now have enough information to answer the essential questions from the first three lessons. Jot down notes to answer these questions.

- How do mutations create species variability?
- Why is sexual reproduction important to the process of evolution?
- How do theories explaining evolutionary change compare?
- What theories are the foundation of modern evolutionary change ideas?
- What proof is there that present-day species evolved from ancestral forms?

2. Brainstorm ways that this information could be in your game, play, or podcast. Talk to other students about their ideas if you need some help.
3. Look back at the project work you placed in your course folder in Lesson 2.
4. Continue creating your game rules/setup or the plot outline for your play.
5. Place what you have completed in your course folder to continue working with in the next lesson.

Discuss

Is the evidence for evolution discussed in this lesson enough to prove to you that evolution occurs? If not, what further evidence do you need? If it is enough evidence, what piece of evidence stood out for you? What area of evidence would you like to explore in more depth? Create a response to these questions, and post your response in the discussion area.

Going Beyond

The organism shown here is unique to the Burgess Shale. Some fossils in the shale have never been found anywhere else in the world. Work collaboratively with students in your class to do some research to find out what unique and interesting fossils have been found in the Burgess Shale. What have scientists learned from these fossils? Why is the Burgess Shale a protected area? Post your information in the discussion area. Create a poster or written summary of the information posted. This may be completed as a group.



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Module 4: Lesson 3 Assignment

Make sure you have completed all of the questions for the Lesson 3 Assignment. Check with your teacher about whether you should submit your assignment now or wait until all of the Module 4 assignments have been completed.



Lesson Summary

In this lesson you explored the following essential question:

- What proof is there that present-day species evolved from ancestral forms?

The Burgess Shale in Yoho National Park is an excellent source of evidence for evolution. If Darwin had access to the fossils in the Burgess Shale, he likely would have had even stronger evidence to support his developing theories. Scientists today have more evidence for evolution than Darwin had.

Scientists have been accumulating evidence of evolution for more than 150 years. Early evidence—such as fossils—led scientists to examine anatomy. Homologous structures, which can be compared between fossils and living organisms, support Darwin's theory that organisms evolve from ancestral forms. Similarities in embryo development (a three-week old human embryo looks similar to a chicken embryo) also seem to support Darwin's theory.

New discoveries and the advancement of technology allow scientists to look at molecular biology and genetics (such as DNA and the process of cellular reproduction) for evidence of evolution. For example, scientists have found that human DNA is 98.8% similar to chimpanzee DNA. This information indicates that at some point there was a common ancestor for the two animals.

In Lesson 4 you will explore how new species form, and you will revisit contrasting ideas about the pace of evolution.

Lesson Glossary

analogous structures: body parts in different species that have similar functions but evolved separately

biogeography: the study of the past and present geographical distribution of species

embryology: the study of similar features in embryos and evolutionary relationships that may exist

fossils: the remains of past life found in sedimentary rock

homologous structures: body parts in different species that have the same evolutionary origins and structural elements but may have different functions

hypothesis: a statement that provides one possible answer to a question or one possible explanation for an observation

inheritance of acquired characteristics: a theory that characteristics acquired during an organism's lifetime could be passed to its offspring

strata: a layer of rock or soil that has a consistent character and is different from layers above and below it

transitional fossil: the remains or impression of a prehistoric organism that shows intermediary links between groups of organisms and shares characteristics common to these groups

Lesson 4—How New Species Form

Get Focused



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What does it take to make a new species? In movies, a radical mutation in human DNA will often create a weird superhuman. Or a human will be infected with an unknown virus and become a blood-seeking creature. This looks great on the big screen, but does it really portray a new species of *homo sapiens*? Maybe, but certain conditions apply—random mutations definitely direct the evolutionary path of **speciation**. However, there are conditions that allow these mutations to create a whole new species.

speciation: the formation of new species

In this lesson you will explore the following essential question:

- What conditions are necessary for speciation?

Module 4: Lesson 4 Assignment

In this lesson you will complete the Lesson 4 Assignment in the Module 4 Assignment Booklet.

- TR 2. Leopard Frogs: One Species or Seven?
- Reflect and Connect



Explore



Read

Darwin's theory of evolution by natural selection included these ideas.

- Life forms have developed from ancestral species.
- All living things are related to one another by varying degrees of common descent.
- All living things on Earth have a common origin or share a common ancestor.
- The mechanism by which one species evolves into another species involves random heritable genetic mutations. Mutations that create a survival advantage are more likely to be passed on to offspring. Eventually, the successful mutation increases in the population and causes the population as a whole to start to change.

What is a species? A species is defined by considering an animal's anatomy, physiology, biochemistry, behaviour, and genetics. And a species is a group of similar organisms that can interbreed to produce **viable offspring** in nature. Viable offspring will live and be able to reproduce to create new offspring. The formation of new species is called speciation. Two forms of speciation are transformation and divergence.

viable offspring:
offspring that are healthy
and able to reproduce and
create new offspring



With transformation, new species arise as a species gradually changes over time and the old species is replaced by the more adapted species. One species evolves into another species (one path).

Inquiry into Biology u2_S4.3_p.137, from McGraw Hill Reproduced by permission.

The evolution of mammoths is an example of speciation by transformation. Read more about this subject on page 136 of the textbook.





Meanwhile, with divergence, new species can arise when barriers prevent populations from reproducing with each other. In this case, two or more species evolve from one parent species (many paths).

The evolution of the Galapagos Island finches is an example of divergence. Read more about this topic in "Figure 4.16" on page 137 of the textbook.

Inquiry into Biology u2_S4.3_p.137, from McGraw Hill Reproduced by permission.



Watch and Listen

What are the requirements for evolution and the creation of a new species? Go to your Biology 20 Multimedia DVD, and view "Speciation."



Read

A population must be isolated in some way for speciation to occur. Read "Keeping Populations Separate" on pages 137 and 138 of the textbook to find out how this isolation can occur. The animation also covers this topic.



Self-Check

SC 1. What two types of barriers can prevent interbreeding?

SC 2. A bird's call can be a barrier to speciation. How?

Check your work with the answer in the appendix.



Watch and Listen

Go to your Biology 20 Multimedia DVD, and view "Divergent Speciation."

Read more about speciation and adaptive radiation on pages 139 and 140 of the textbook.



Self-Check

SC 3. Give an example of adaptive radiation.

SC 4. Why is this species an example of adaptive radiation?

Check your work with the answer in the appendix.



Try This

TR 1. Biological Barriers

Go to the Biology 20 Multimedia DVD, and print or save a copy of the "Biological Barriers" handout. Read and answer the questions. Save this data in your course folder. Compare your answers with the answer key, which you will also find on the Biology 20 Multimedia DVD. This will be a helpful review and may be used in your Module Project.



Watch and Listen

Speciation caused by a geographical barrier is sometimes referred to as **allopatric speciation**. The cichlids (a genus of fish) in Lake Victoria are an example of allopatric speciation. Go to www.mhhe.com/biosci/genbio/espv2/data/evolution/003/index.html, and watch the example of how a geographical barrier can cause allopatric speciation in a population of lizards. Choose "3.71 Allopatric Speciation" from the list.

allopatric speciation:
speciation caused by a
geographic barrier



Try This

TR 2. Leopard Frogs: One Species or Seven?

Have you ever considered that not all "ribbits" sound the same? In fact, they can be very different. Read "Thought Lab 4.5" on page 139 of the textbook. Go to your Biology 20 Multimedia DVD, and open the "Frog Calls" player. Pick any two species of leopard frog to comment on in the Lesson 4 Assignment.



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**Read**

You have already looked at the theory of punctuated equilibrium vs. gradualism in Lesson 2. You may wish to refresh your memory and reread pages 140 and 141 of the textbook. If you would like to learn more about punctuated equilibrium, try typing the keywords “punctuated equilibrium” into the pbs.org website. Now that you know more about how new species arise, are you more inclined to follow one theory?

**Self-Check**

SC 5. Which of the two models, gradualism or punctuated equilibrium, suggests that species undergo most of their changes when they first diverge from the ancestral parent species?

Check your work with the answer in the appendix.

**Reflect and Connect**

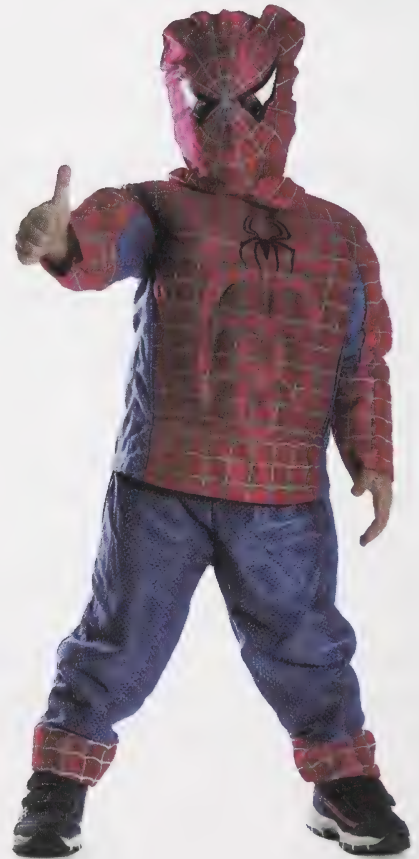
What conditions would need to be present for Peter Parker to become a new species as Spiderman? Outline a scenario in a storytelling format (e.g., as a cartoon, a creative writing piece, a video, or an audio) that would describe how the “spiderman” species could evolve from the current population of humans. Be creative, but don’t get carried away—this is designed to be a short piece.

OR

Create your own scenario outlining the evolution of a new species by using a storytelling format of your choice.

You will be completing this activity in your Module 4: Lesson 4 Assignment.

The following rubric will determine your mark for this exercise.



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Category	4	3	2	1
Requirements The scenario presented explains how a new species is formed. Genetic variation/ diversity, reproductive isolation, barriers, and speciation are presented in context. This is presented in a storytelling format.	The requirements are met and exceeded.	All requirements are met.	One requirement was not completely met.	More than one requirement was not completely met.
Content	The topic is covered in-depth with details and descriptions. The student's subject knowledge is excellent.	Essential knowledge about the topic is included. The student's subject knowledge appears to be good.	Essential knowledge is included about the topic, but there are one or two factual errors.	The content is minimal, or there are several factual errors.
Presentation				



Self-Check

SC 6. As a final check of what you have learned in this lesson, go to the Biology 20 Multimedia DVD, and complete the "Butterfly Self-Check."



Reflect on the Big Picture

Module Project

Consider how to bring the concept of "barrier" into your game.

Maybe your game players will diverge into a new species when they land on the "barrier" square. Will your play characters debate the merits of one model over the other, or even act out the punctuated equilibrium

theory? There are so many possibilities—what will you do? These are just some ideas you may use, or not use, to help finish your game, play, or podcast.

Complete the Module Project.

1. You now have the information to answer the final question for this project. Jot down important information that answers the last question: What conditions are necessary for speciation?
2. Brainstorm ways to include this information into your project in a creative way.
3. Retrieve your project materials from your course folder.
4. Complete the project.
5. Have you referred to the marking rubric to self-assess your project? If not, do so now.
6. Submit the finished project to your teacher as your module assessment. Share your projects with your classmates.



Going Beyond

The fossil record indicates that humans have changed over time. The documentary titled “Becoming Human” explores the evidence for human evolution, anatomical differences between modern-day humans and their ancestors, human lineages, and cultural evolution. You will travel with paleontologists across continents, visit dig sites, and look at ancient fossils of early humans.

As you view the documentary, pay attention to the changes in structure and culture that make people what they are today. To access this video, type in the keywords “becoming human documentary.”

This website has lots of information that is interesting and worthwhile to view.



Self-Check

Go to your Biology 20 Multimedia DVD, and complete the "Becoming Human Self-Check."



Module 4: Lesson 4 Assignment

Remember to submit the Assignment answers to your teacher as part of your Module 4: Lesson 4 Assignment.



Lesson Summary

In this lesson you explored the following essential question:

- What conditions are necessary for speciation?

Divergence and transformation are the two pathways in which new species can evolve. All of the estimated two to 100 million species in the world have evolved from these two pathways. But in order for a species to diverge or transform, certain conditions must be present.

Essential to evolution is genetic diversity. A population must have genetic variation in order for any kind of change to be possible. Mutations, sexual reproduction, and recombinations provide this genetic diversity.

An environment must change in some way in order for certain characteristics to become dominant in a population. The change in environment (either geographical or biological) must create reproductive isolation. This isolation prevents the two populations from exchanging genetic information. Adaptations in each population can eventually lead to the genesis of a new species. Speciation has occurred if the two populations can no longer mate successfully.

Now that you have completed the last lesson of Unit B: Module 4, there are three things you need to do.

First, hand in your Lesson 4 Assignment.

Second, you have been working on a module project. It is now time to finish your play, game, or podcast. This has been discussed in Reflect on the Big Picture.

Finally, you need to head to the Unit Summary and Assessment. There you will find a Unit Assessment that you should start working on.

Once all of these tasks have been completed, you will be ready to move from “Ecosystems and Population Change” to “Photosynthesis and Cellular Respiration.”

Lesson Glossary

allopatric: speciation that occurs from a geographical barrier

barrier: anything that prevents organisms from reproducing

biological barrier: a factor such as behaviour that keeps species reproductively isolated even when they exist in the same region

divergence: the development of one or more new species from a parent species as a result of mutation and adaptation to changing environmental conditions: the parent species continues to exist

geographical barrier: geological formations that keep organisms separated

gradualism: the theory that evolution occurs slowly and steadily in a linear fashion

punctuated equilibrium: the theory that suggests that evolutionary history consists of long periods of stasis (stable equilibrium), punctuated by periods of divergence

speciation: the formation of new species

transformation: the evolution of one species into another as a result of mutation and adaptation to changing environmental conditions, resulting in the replacement of the old species

viable offspring: offspring that are healthy and able to reproduce and create new offspring

Module 4—Mechanisms of Population Change

**Module Summary**

“It is not the strongest of the species that survives, nor the most intelligent that survives. It is the one that is the most adaptable to change.”

Charles Darwin – The Origin of Species

In this module you studied the mechanisms of population change and learned how changes in population can lead to evolution. Evolution is the change in populations over time. Variations are essential to a population’s survival. The variations or differences between individuals are created through sexual reproduction and mutations. Populations with greater variation are more likely to survive if their environment changes. Variations that give an organism an advantage are called adaptations.

In Lesson 2 of this module, you investigated past and present theories on which biologists base their theories. Two early theorists—Lamarck and Darwin—proposed theories of evolution and population change. A comparison of these two scientists showed that they had different ideas about how population characteristics changed over time. Darwin’s theory of natural selection is the theory that is widely accepted today, and it is used to explain how nature is involved in population change.

Throughout this module you read articles and viewed examples of populations evolving. These changes were explained by the theory of natural selection. Natural selection dictates that organisms most suited to survive in an environment because of their adaptations will live to reproduce and pass on these adaptations. Today’s scientists also have two theories proposing the rate of evolution. You studied the two different models—gradualism and punctuated equilibrium. The gradualism model describes evolution as a slow, steady, and continuous process; whereas the punctuated model describes evolution as a process that occurs in rapid bursts followed by long periods of little change. The speed at which evolution occurs is still up for debate, but scientists agree that populations have changed over time and evolution has occurred.

There is much evidence to support evolution. Some of this evidence was studied in Lesson 3. The fossil record has given scientists information about evolution for many years. Comparative anatomy and embryology are useful tools for distinguishing evolutionary relationships between different species of organisms.

Biogeography, genetics, and biochemistry are some other areas of study where evidence for evolution can be found.

In the final lesson of this module, you learned about the methods by which new species can evolve. In order for change to occur, variation must be present in a population. There also must be environmental changes that encourage natural selection. Finally, there must be reproductive isolation. Barriers, such as geographical isolation or biological isolation, effectively prevent two populations from interbreeding. Over time, each population adapts to its environment. If the adaptations have become so different that successful mating will not occur, then speciation has taken place.

This module has allowed you to investigate the history of organisms on Earth. It also allows you to explain the process of evolution by looking at scientific theory and evidence supporting those theories. With this

information, you can predict possible evolutionary outcomes based on your knowledge of natural selection and speciation.

Module Assessment

Module Project

Submit your Module Project to your teacher to be marked. Make sure that all of the following items have been covered. You will be working on this project through each lesson. At the end of Lesson 4 you will need to prepare the game, play, or podcast for submission. Use the self-evaluative chart to support a reflection on how well you used the focus questions in this project. Your teacher may request that your project be posted or shared with your peers.

Purpose: Demonstrate your understanding of Module 4 by creating a game, podcast, or play that will educate people about evolution in a creative, fun, and entertaining way.

Requirements: The questions from the Get Focused section at the beginning of each lesson must be answered and explored while playing the game or watching the play or podcast. A checklist follows that is designed to help ensure you have included the necessary information in this project.

Choose Option A or B.

Option A—The Game of Evolution

Game Specifics

- The game must be “playable.”
- The game may be a board game, a card game, a trivia game, or in an electronic format. You may modify an existing game to meet your needs.
- A list of game rules should be included.
- The game board and pieces should all be based on a theme (something to do with evolution).
- The game must educate and entertain.
- All seven questions (in the following table) must be addressed and understood by the players by the end of the game.
- A completed copy of the Project Questions Self-Checklist and Marking Rubric must be included with your project.

Option B—Evolution: The Play or Podcast**Play Specifics**

- The play may be in the form of a manuscript or an audio or video recording.
- You may modify an existing play to meet your needs or create an original play.
- The play must educate and entertain.
- All seven questions (in the following table) must be addressed and understood by the audience at the end of the play.
- A completed copy of the Project Questions Self-Checklist and Marking Rubric must be included with your project.

Project Questions Self-Checklist

Check the appropriate box.

Questions to Be Explored and Answered in the Project	I thoroughly and correctly explained this question.	I correctly explained this question.	I made an attempt to explain this question.	I did not attempt to explain this question.
How is sexual reproduction significant in creating variation within populations?				
How can mutations improve or harm an individual organism's chance for survival and reproduction?				
How do variations lead to evolution of populations?				
How do the Lamarckian and Darwinian explanations of evolutionary change compare?				
What evidence exists to support the theory of evolution?				
What is speciation and what conditions are required for this process?				
How do scientists currently explain evolution?				

Marking Rubric

	4	3	2	1	
Questions to Be Explained and Answered	All seven questions are thoroughly explained and answered by playing or watching the project.	Most of the seven questions are explained and answered by playing or watching the project.	Some of the seven questions are explained and answered by playing or watching the project.	Few or none of the seven questions are explained and answered by playing or watching the project.	_____ x 5 = ____/ 20
Scientific Content	The scientific content is correct and at an appropriate level for a Biology 20 student.	The scientific content is mostly correct and at an appropriate level for a Biology 20 student.	The scientific content has some errors.	The scientific content contains many errors.	_____ x 2 = ____/8
Entertainment Value	The project was very entertaining and fun.	The project was entertaining.	The project had some entertainment value.	The project showed little or no entertainment value.	_____ x 1 = ____/4
				PROJECT TOTAL	_____ 32

Unit B Conclusion

If asked to describe how the biosphere is composed of ecosystems, each with distinctive biotic and abiotic characteristics, you could refer to the differences between Earth's biomes. You have learned that the abiotic components, like precipitation and altitude, will influence the distribution of the biotic components, such as animals and plants. Aquatic and terrestrial biomes and ecosystems can be identified by looking at the particular mix of organisms that have adapted to living in a particular environmental condition. You have learned that the abiotic environment influences where organisms will live and survive. Your Module 3 project explored how humans can apply this knowledge of the components of ecosystems to assess and limit the impact of human activities in national parks.

In Unit B you have performed a variety of labs and learned many techniques used to study the different components of ecosystems. You have researched how scientists determine the distribution and abundance of organisms and how these organisms are classified, identified, and named. If you were to perform a field study looking at the diversity of organisms in an area, you could now determine an appropriate method for measuring the distribution and abundance of organisms. Transects, quadrats, and catch/recapture are some of the sampling techniques you might choose from.

When asked to explain the mechanisms involved in the second major concept—the change of populations over time—you will describe the process of natural selection. You may explain the theory of natural selection better by comparing the different theories of evolution proposed by Lamarck and Darwin. You will discuss the importance of sexual reproduction and mutations in creating variation in populations and how this is necessary for the process of evolution. Since evolution can be a controversial topic, it is important that you understand the evidence used to support the evolution of modern species from ancestral forms. Evidence like the fossil record, homologous and analogous structures, and biochemistry can now be described. You should also be able to explain the two modern evolutionary theories of punctuated equilibrium and gradualism.

Now that you have completed Unit B, you know where ecosystems are found, what the biotic and abiotic components are, and some of the interactions that occur between these components. Describing how these interactions can lead to the change of populations over time or evolution helps you to make your own conclusions about evolution as a product of natural selection.

In Unit C you will take a closer look at the interaction between two components found in every ecosystem—sunlight and plants. You will look at how plants (the biotic component) and sunlight (the abiotic component) are directly linked to each other and the other organisms in the ecosystem.

Unit B Assessment

Part A—Module Concept Maps

Concept maps at the end of Chapters 3 and 4 of your textbook (pgs. 109 and 143) give you an overview of the lessons. Recreate each of these concept maps in a paper or electronic format using a word-processing program or drawing program. For each topic given in the map, add a new example of this topic and a definition or

explanation in your own words. Your concept maps will become very large, so be sure to organize your work well. **Hint:** If you are creating an electronic flow chart, you may find inserting “comments” the easiest way to add more information to your chart.

Connect your concept maps, and indicate where appropriate links between Module 3 and Module 4 could be made. Explain your reasoning.

Compare your expanded concept maps with other students’ maps before submitting them to your teacher.

Rubric

CATEGORY	4	3	2	1
Organization	Information is very organized and easily viewed.	Information is organized and easily viewed.	Information is a bit confusing and disorganized.	The information appears to be disorganized.
Connections	Connection between modules is very logical and thoroughly explained.	Connection between modules is logical and explained.	Connection between modules is poorly explained but correct.	Connection between modules is not explained or is incorrect.
Amount of Information	An example and definition have been added to the chart for each topic.	One or two examples and definitions have been missed.	Three or four examples and definitions have been missed.	More than five examples and definitions have been missed.
Quality of Information	Definitions and examples clearly represent the topics.	Definitions and examples relate to the topics.	Some definitions and examples are not related to the topics.	Information has little or nothing to do with the topics.
Definitions	All definitions are clear and are in the student’s own words.	Most definitions are correct and are in the student’s own words.	Some definitions are correct and are the student’s own words.	Definitions are not written in the student’s own words.

Part B—Textbook Review

Answer and submit the following textbook questions to your teacher for marking.

Page 148: questions 1, 4 or 5, 6 or 9, 7, 11, 14, 15, 16, 17, 20, 21, 25, 26, 27, 28, 34, 41, 43, 46, 47, and 49

After the questions have been submitted and marked, make any corrections and then work on Part C of the Unit Assessment.

Part C—Linking It All Together

During this unit assessment you must think like an ecologist and an evolutionary biologist. It is very common for these two biological disciplines to be combined into one department at a university. You will be expected to use the knowledge gained from Modules 3 and 4 to complete this project.

The final evaluation for this unit will be in one of the following forms: written report, oral report, or PowerPoint presentation. The report should be short and precise—no more than 250 words. Descriptions and/or explanations of concepts should include pertinent ideas and pictures. Your response must be presented in a well-organized manner using complete sentences. Relevant scientific and technological concepts must be clear and correct.

A Report on the Ecology and Predicted Evolution of a Species

Complete and include each of the following steps in your report:

- Choose any species of organism that interests you. Give its scientific classification and name. (2 marks)
- Describe the biotic and abiotic components of its ecosystem. (2 marks)
- Choose one biotic or abiotic factor that limits a population of this species from increasing in density. (1 mark)
- Hypothesize how this factor could change the variation in the population over time. (1 mark)
- Detail how this factor, through the process of natural selection, will cause the population to evolve. (4 marks)

Report Marking Guide

CATEGORY	4	3	2	1
Organization	Information is very organized with well-constructed paragraphs and subheadings.	Information is organized with well-constructed paragraphs.	Information is organized, but paragraphs are not well-constructed.	The information appears to be disorganized.
Amount of Information	All steps are addressed and all questions are thoroughly answered.	All steps are addressed and questions are answered.	All steps are addressed and most questions are answered.	One or more steps were not addressed.
Quality of Information	Information clearly relates to the steps. It includes several supporting details.	Information clearly relates to the steps. It provides some supporting details.	Information clearly relates to the steps. No details are given.	Information has little or nothing to do with the steps.
Scientific Knowledge 10 points	The student will receive a mark out of 10 points based on the scientific knowledge presented throughout the report and based on the accuracy of the information presented. Refer to the question in Unit Assessment—Part C for an allocation of these marks.			
Total	_____ / 22			

Module Glossary

adaptation: a beneficial variation that helps an organism survive

allopatric: speciation that occurs from a geographical barrier

analogous structures: body parts in different species that have similar functions but evolved separately

barrier: anything that prevents organisms from reproducing

biogeography: the study of the past and present geographical distribution of species

biological barrier: a factor such as behaviour that keeps species reproductively isolated even when they exist in the same region

divergence: the development of one or more new species from a parent species as a result of mutation and adaptation to changing environmental conditions: the parent species continues to exist

embryology: the study of similar features in embryos and evolutionary relationships that may exist

fossils: the remains of past life found in sedimentary rock

geographical barrier: geological formations that keep organisms separated

gradualism: the theory that evolution occurs slowly and steadily in a linear fashion

gradualism: gradual change occurs in a steady, linear way over time

homologous structures: body parts in different species that have the same evolutionary origins and structural elements but may have different functions

hypothesis: a statement that provides one possible answer to a question or one possible explanation for an observation

inheritance of acquired characteristics: a theory that characteristics acquired during an organism's lifetime could be passed to its offspring

mutagen: something that causes an increased rate of mutation

mutation: a change in the genetic material of an organism (DNA)

natural selection: the process that results when the characteristics of a population of organisms change because individuals with certain inherited traits survive specific local environmental conditions and, through reproduction, pass on their traits to their offspring

paleontology: the study of ancient life through the examination of fossils

punctuated equilibrium: evolutionary history is said to consist of long periods of equilibrium, interrupted by periods of speciation

punctuated equilibrium: the theory that suggests that evolutionary history consists of long periods of stasis (stable equilibrium), punctuated by periods of divergence

selective advantage: an organism's variations increase its chances of surviving

selective disadvantage: an organism's variations reduce its chances of surviving

selective pressure: environmental conditions that select for certain characteristics of individuals and select against other characteristics

sexual selection: a type of natural selection where characteristics are selected based on mate preferences

speciation: the formation of new species

strata: a layer of rock or soil that has a consistent character and is different from layers above and below it

transformation: the evolution of one species into another as a result of mutation and adaptation to changing environmental conditions, resulting in the replacement of the old species

transitional fossil: the remains or impression of a prehistoric organism that shows intermediary links between groups of organisms and shares characteristics common to these groups

variation: visible or invisible differences between individuals

viable offspring: offspring that are healthy and able to reproduce and create new offspring



Self-Check Answers

Lesson 1

SC 1. Yes. Smell helps sharks survive by being able to find food.

SC 2. Kittens with the same parents can have many different looks based on the inherited combinations of genes that can occur during sexual reproduction.

SC 3. A mutation in a somatic cell cannot be passed on to the next generation. A mutation in a reproductive cell may be passed on to succeeding generations.

SC 4. An example of a selective advantage is a mutation in houseflies. This mutation makes the insects resistant to the insecticide called DDT. This situation is only advantageous if DDT is being used because the flies with the mutation will have a better chance of survival and reproduction (survival of the fittest).

SC 5. An example of a selective disadvantage can also be the mutation in houseflies that makes them resistant to DDT. This mutation reduces the growth rate of these flies. If DDT is not present, those flies will be less likely to survive and reproduce because of their size (survival of the fittest).

	4	3	2	1
Accuracy of Explanation	The explanation is very accurate and detailed.	The explanation is accurate and detailed.	The explanation is accurate.	The explanation is inaccurate.
Clarity of Explanation	The explanation is very easy to interpret and understand.	The explanation is easy to interpret and understand.	The explanation is somewhat difficult to understand.	The explanation is difficult to understand.

Lesson 2

SC 1. Cuvier would have suggested the species of fish had become extinct, possibly due to a natural catastrophe such as a flood or a volcanic eruption.

SC 2. Lyell rejected the idea of catastrophism and guessed that Earth changed slowly and continuously over time. His idea also suggested that Earth was older than 6000 years. He believed that slow, continuous change would amount to large changes over time. This influenced other thinkers, such as Charles Darwin, who wondered if the same sort of processes and timelines were also occurring in populations.

Lesson 3

SC 1. *Archaeopteryx* has characteristics of both reptiles (dinosaurs) and birds. It had feathers, but it also had teeth, claws, and a bony tail.

SC 2. They broke apart from 110 to 120 million years ago.

SC 3. India became part of Asia from 23 to 30 million years ago.

SC 4. Africa and South America were once joined in one “supercontinent.”

SC 5. Antarctica and the North Pole were not connected when penguins and polar bears evolved.

SC 6. The wing examples are both analogous structures—they perform similar functions (flying) but do not have a common evolutionary origin.

Lesson 4

SC 1. A geographical barrier keeps populations physically separated from one another. Examples include canyons, mountain ranges, water between islands, large lava flows, and glaciers.

With a biological barrier, organism ranges may overlap but biological barriers prevent reproduction. Courtship/mating rituals, pheromones, behaviour, niche/habitat preferences, and reproductive anatomy differences are examples of biological barriers.

SC 2. Bird calls play a large role in mate selection. Variations in calls may affect the ability of males to attract female mates. Intraspecific variations in calls can lead to reproductive isolation.

SC 3. Darwin’s finches or the *Drosophila* fly of the Hawaiian Islands are examples of adaptive radiation.

SC 4. Both species had an original isolated population on one island. The species proliferated on the first island and then began to disperse to other islands. They adapted to the different conditions on each separate island. Various selective pressures resulted in different feeding and mating habits.

SC 5. Punctuated equilibrium is the correct answer.

